

Waste Management Efficiency in Semarang

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WASTE MANAGEMENT EFFICIENCY IN SEMARANG

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ABSTRACT

In this paper aim is to measure the efficiency of waste management in Semarang, Indonesia. Data Envelopment Analysis (DEA) was used in this study to measure the relative efficiency between Sub-Districts as DMU (Decision Making Unit). The variable inputs used are trash bins, trash rickshaws, arm roll trucks and containers. The output of the variables used is the volume of waste produced in each Sub-District. Analytical study. This research was carried out in the range of 2004 - 2014. The total data is 176. DEA analysis in this study uses two models, namely the CCR model assuming Constant Return to Scale and the input-oriented BCC model with the assumption of Return to Scale Variables. The number of DMUs that are efficient in the input-oriented BCC model is more than the CCR model.

Keywords: waste management, efficiency, DEA, BCC model, CCR model.

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1. INTRODUCTION

Municipal Solid Waste Management (MSWM) is a principle for managing solid waste in urban areas. Management of municipal solid waste requires proper infrastructure, maintenance, and quality improvement in every waste processing activity. Management of municipal solid waste

becomes more expensive and complex due to sustainable waste growth and the complexity of urban problems (Sharholy, Ahmad, Mahmood, & Trivedi, 2008) [1].

Waste management in Indonesia is regulated by Law No. 18 of 2008 concerning Waste Management. Operational engineering activities for urban waste management in waste management systems in Indonesia must be integrated, consisting of landfill activities to waste final disposal (National Standards Agency, 2013) [2]. Meanwhile, in the Semarang City, as one of the cities in Indonesia, waste management is regulated in the Regional Regulation No. 6 of 2011 concerning Waste Management. In the regional regulation, it is stated that everyone is obliged to reduce and handle waste in an environmentally sound manner.

In fact, the responsibility for waste management has been borne by the government. The role of government is very important in the provision of solid waste infrastructure, as a form of government service to the community (Callan & Thomas, 2013) [3]. Reality shows that inadequate equipment capacity and lack of equipment maintenance are found in many areas. Procurement of goods by the government is constrained by complex systems. This is one of the government's failures to create optimal conditions (Hyman, 2014) [4]. According to (Faizah, 2008) [5], the government's role in managing waste only reaches 40.09% in urban areas and 1.02% in rural areas.

The increase in the volume of urban solid waste is due to several interrelated parameters, namely population growth (Yüksel, 2012) [6], economic growth (Okumura, Tasaki, Moriguchi, & Jangprajak, 2016) [7], community economic activity (Sjöström & Östblom, 2010) [8] and consumption (Anderson, 2013) [9]. Increased waste volume is not balanced with waste management.

Waste management in developing countries is faced with complex problems such as increasing solid waste generation, non-long-term waste management rules, waste collection and unfavorable waste transportation, poor final processing, low technology, and lack of community awareness in managing waste (Guerrero, Maas, & Hogland, 2013) [10]. Waste management is still done conventionally, where waste is concentrated in the landfill. If the waste is only concentrated in the landfill, it can shorten the life of the landfill and have an impact on environmental pollution, both water, soil and air, so that waste has the potential to reduce the quality of natural resources, cause flooding and social conflict, and cause various diseases (Keim, 2008) [11].

One of the developing countries is Indonesia, and one of the cities is Semarang City. Semarang City is the capital of Central Java Province. Semarang city is the biggest waste producer in Central Java. Semarang City is between the lines 6⁰50' - 7⁰10' South Latitude and the lines of 109⁰35' - 110⁰50' East Longitude (Central Bureau Statistics, 2014) [12]. The trigger for the amount of waste in Semarang City is the increase in population, it was noted that in 2011 the population of Semarang City reached 1,544,358 inhabitants, in 2012 there were 1,559,198 inhabitants and in 2013 there were 1,572,105 inhabitants.

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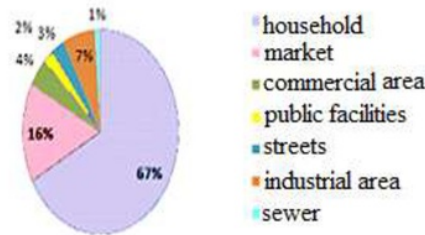


Figure 1. Source of Waste Generation in Semarang at 2013

Source: (Central Bureau Statistics, 2014) [12]

Figure 1 shows that the biggest waste comes from residential / household and at least comes from the channel. Sources of waste generation in Semarang City come from settlements (households), markets, commercial (shops, restaurants, hotels), public facilities, sweep roads, industrial areas (Non-Hazardous and Toxic Materials) and channels.

The waste can be in the form of organic waste and inorganic waste. Inorganic waste consists of paper, glass, plastic, metal, cloth, rubber and others. Organic waste as the biggest contributor to waste generated in Semarang City is 78.34%, while the remaining 21.66% is non-organic waste (Central Bureau of Statistics, 2014) [12]. The details of the waste composition are presented in the following Figure 2:

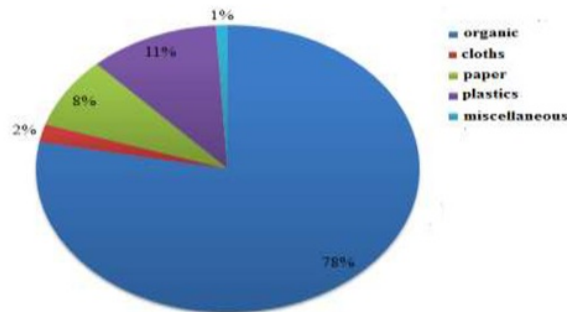


Figure 2. Details of Waste Composition in Semarang at 2013

Source: (Central Bureau Statistics, 2014) [12]

According to Figure 2, organic waste dominates the type of waste in the city of Semarang. Organic waste comes from household waste. Meanwhile, the most inorganic waste is plastic waste. Waste management in Semarang City both from households, commerce and social facilities is mostly disposed at Jatibarang Landfill. Waste problems in Semarang City are even more concerning because Semarang City produces 800 to 1,000 m³ of waste every day. However, the average transported to the Jatibarang Landfill is only 750 tons/day and the waste management capacity is only 400 tons/day. This problem occurs because the availability of infrastructure for waste management is still insufficient (Alfi, 2013) [13].

Waste management in Semarang City is handled by the Hygiene and Landscaping Agency. According to data from the Hygiene and Landscaping Agency of Semarang City, in 2013 the number of waste transport fleets, namely armroll and dump, was reduced due to damage. In

2012, the number of truck armrolls was 85 units and dump trucks were 21 units. The decrease in the number of fleets is also a constraint to the transportation of waste in the city of Semarang.

The conditions that occur are the lack of the transportation of waste. That is not according to the target of the Hygiene and Landscaping Agency of Semarang City, so that waste accumulates and disrupts the collection schedule. In addition, the condition of the truck, containers and many waste bins are also damaged. There are differences in the number of containers and of waste transportation in each Sub-District.

So that there is an imbalance in waste management (The Hygiene and Landscaping Agency, 2013) [14]. This condition causes waste that has not been handled because the volume of waste continues to increase along with the increase in population. The waste that was not handled in Semarang City in 2014 was around 822.17 m³ or 182.73 tons from 4,836.30 m³ (Central Bureau Statistics, 2016) [15]. The area of Jatibarang Landfill is 276,469.8 m² for waste land, 46,018 m² for leachete pond infrastructure, 46,018 m² for green belt and 46,018 m² for cover land. Solid waste entering the landfill per day is 1,000 tons per day. The Jatibarang Landfill began operation in 1992. The life span of the Jatibarang Landfill is only 4 to 5 years (with the current management system) (The Hygiene and Landscaping Agency, 2017) [16].

2. MATERIAL AND METHOD

This study uses secondary data sourced from the Hygiene and Landscaping Agency of Semarang City which includes data on the volume of waste per day and means of handling waste consisting of trash bins, trash rickshaws, containers and arm roll trucks owned by each Sub-District in Semarang City for 11 years, 2004 - 2014.

The input variables used are waste infrastructure, namely trash bins, trash rickshaws, containers and truck arm roll, while the output variable is the volume of waste generation. The DMU of this research is all Sub-Districts in Semarang City. The Sub-Districts are Ngalian Sub-District, Mijen Sub-District, Gunungpati Sub-District, Banyumanik Sub-District, Gajah Mungkur Sub-District, South Semarang Sub-District, Candisari Sub-District, Tembalang Sub-District, Pedurungan Sub-District, Genuk Sub-District, Gayamsari Sub-District, East Semarang Sub-District, North Semarang Sub-District, Central Semarang Sub-District, West Semarang Sub-District, Tugu Sub-District.

The analytical tool used is Data Envelopment Analysis (DEA). DEA is a linear programming methodology for measuring and evaluating the relative efficiency of a series of Decision Making Units (DMU). The efficiency of the DMU assessed in the DEA is the ratio of total output to total input [6]. The root of the DEA principle is based on research conducted by Farrell in 1957 (Farrell, 1957) [17].

There are two models for measuring efficiency using the DEA, namely the CCR created by Charnes, Cooper and Rhodes in 1978 (Charnes, Cooper, & Rhodes, 1978) [18] and the BCC created by Banker, Charnes and Cooper in 1984 (Banker, Charnes, & Cooper, 1984) [19]. The CCR model is assumed to be a constant return to scale (CRS). If there is an additional input of x times, so it will produce an output that will increase x times as well. The BCC model is assumed to be a variable return to scale (VRS). If there is an additional input of x times, so it will produce output with an increase or decrease compared to additional inputs.

The DEA formulation with the CCR model is as follows:

Min θ

$$\text{subject to } \sum_{j=1}^n \lambda_j X_{i,j} - \theta \cdot X_{i,j} \leq 0$$

$$\sum_{j=1}^n \lambda_j Y_{r,j} - Y_{r,j} \geq 0$$

$$\sum_{j=1}^n \lambda_j \geq 0$$

where :

- θ : scalar
 n : number of DMUs
 $X_{i,j}$: input (X) i used by DMU j
 $Y_{r,j}$: output (Y) r produced by DMU j
 λ : weight

The DEA formulation with the BCC model is as follows:

Min θ

$$\text{subject to } \sum_{j=1}^n \lambda_j X_{i,j} - \theta \cdot X_{i,j} \leq 0$$

$$\sum_{j=1}^n \lambda_j Y_{r,j} - Y_{r,j} \geq 0$$

$$\sum_{j=1}^n \lambda_j = 1$$

$$\sum_{j=1}^n \lambda_j \geq 0$$

where :

- θ : scalar
 n : number of DMUs
 $X_{i,j}$: input (X) i used by DMU j
 $Y_{r,j}$: output (Y) r produced by DMU j
 λ : weight

3. RESULTS AND DISCUSSION

Municipal solid waste in the Semarang City as a problem. The volume of the generation continues to increase along with the progress of Semarang City. Not all solid waste are transported to the Jatibarang Landfill.

Based on DEA analysis with Banxia Frontier Analys 3 Professional version 3.2.2 software, the value of waste management efficiency per Sub-District in Semarang City with the assumption of CCR and input oriented BCC are:

Table 1. Efficiency Calculation Results with CCR Model

| Number | Sub-District | Achievement of the Efficiency Value of the CCR Model |
|---|----------------------|--|
| 1 | Ngalian (2010) | 100% |
| 2 | Ngalian (2014) | 100% |
| 3 | Tugu (2014) | 100% |
| 4 | Tugu (2008) | 100% |
| 5 | Ngalian (2009) | 100% |
| 6 | Ngalian (2006) | 100% |
| 7 | Ngalian (2013) | 100% |
| 8 | West Semarang (2007) | 100% |
| Average efficiency achievement with the CCR model | | 99.60 |

Note: years in parentheses indicate the year of analysis, for example, Mijen (2007) then Mijen Sub-District in 2007

The results of the calculation of efficiency analysis with the CCR model shown in Table 1 show that during the 11 years of analysis there were 8 Sub-Districts (DMU) that are efficient or as much as 4.5% and 168 Sub-Districts (DMU) which are inefficient or as much as 95.5%.

Table 2. Efficiency Calculation Results with Input Oriented BCC Model

| No. | Sub-District | Achievement of Efficiency Value of Input Oriented BCC Models | No. | Sub-District | Achievement of Efficiency Value of Input Oriented BCC Models |
|-----|----------------|--|-----|----------------------|--|
| 1 | Tugu (2004) | 100% | 20 | Tembalang (2007) | 100% |
| 2 | Tugu (2008) | 100% | 21 | Pendurungan (2014) | 100% |
| 3 | Tugu (2014) | 100% | 22 | Pendurungan (2011) | 100% |
| 4 | Tugu (2007) | 100% | 23 | Ngalian (2009) | 100% |
| 5 | Tugu (2006) | 100% | 24 | Ngalian (2012) | 100% |
| 6 | Tugu (2005) | 100% | 25 | Ngalian (2013) | 100% |
| 7 | Ngalian (2006) | 100% | 26 | West Semarang (2007) | 100% |
| 8 | Ngalian (2010) | 100% | 27 | West Semarang (2013) | 100% |
| 9 | Ngalian (2014) | 100% | 28 | Tugu (2011) | 100% |

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Continued Tabel 2

| No. | Sub-District | Achievement of Efficiency Value of Input Oriented BCC Models | No. | Sub-District | Achievement of Efficiency Value of Input Oriented BCC Models |
|--|-------------------------|--|-----|----------------------|--|
| 10 | West Semarang (2014) | 100% | 29 | Tugu (2010) | 100% |
| 11 | West Semarang (2012) | 100% | 30 | Tugu (2013) | 100% |
| 12 | Mijen (2007) | 100% | 31 | Tugu (2012) | 100% |
| 13 | Mijen (2013) | 100% | 32 | Tugu (2009) | 100% |
| 14 | Genuk (2004) | 100% | 33 | Genuk (2006) | 100% |
| 15 | Gajah Mungkur (2007) | 100% | 34 | Ngalian (2005) | 100% |
| 16 | Central Semarang (2004) | 100% | 35 | Gunungpati (2014) | 100% |
| 17 | Central Semarang (2007) | 100% | 36 | Gayamsari (2009) | 100% |
| 18 | Gayamsari (2008) | 100% | 37 | East Semarang (2005) | 100% |
| 19 | North Semarang (2009) | 100% | 38 | Banyumanik (2012) | 100% |
| | | | 39 | Banyumanik (2007) | 100% |
| The average efficiency achievement of the input oriented BCC model | | | | | 99.88% |

Table 2 shows the efficiency gains with the BCC input orientation model. The results show that during the 11 years of analysis, there were 39 Sub-Districts from 176 efficient Sub-Districts or around 22.16% while the inefficient ones were 77.84%.

In accordance with these two models, the amount of inefficient data is more than the efficient one. This shows that the generation of solid waste continues to increase every day along with the increase in population and economic activity of the population while the facilities for collecting garbage are relatively fixed. The BCC model shows that the efficient Sub-District is less than the inefficient one, so it shows that the role of the government as a provider of public goods including waste collection infrastructure lack still. This condition is one of the government's failures in creating optimal conditions (Hyman, 2014) [4].

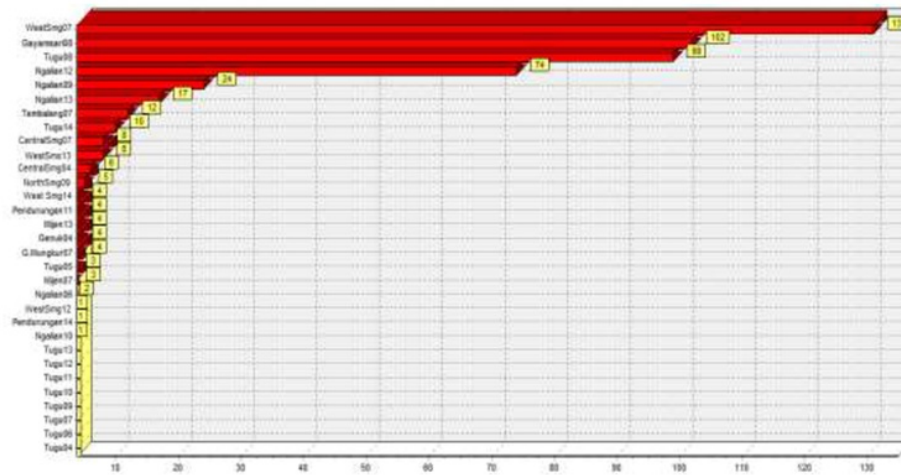


Figure 3. Sub-Districts/Cities in Central Java that Become References Input Oriented BCC Model

Source: own estimation, 2017

The five most Sub-Districts as references according to Figure 3 are West Semarang (2007), Tugu (2008), Ngalian (2009), Tembalang (2007), and Central Semarang (2007). Sub-Districts that are references are Sub-Districts that achieve relative efficiency compared to other Sub-Districts that are inefficient and have good performance compared to other Sub-Districts. Inefficient Sub-Districts are expected to refer to Sub-Districts that have been efficient. Based on the BCC model, the input orientation is that West Semarang Sub-District (2007) is referred to by 131 other sub-Sub-Districts. West Semarang Sub-District (2007) has relatively efficient management performance compared to others.

4. CONCLUSION

Waste management in the city of Semarang has not been efficient. The condition of waste infrastructure in the city of Semarang has suffered many damage, and trucks that operate are not optimal in transporting garbage to the landfill. Infrastructure facilities used should be rejuvenated or renewed and adapted to a wide range of service areas. The inefficiency of waste management in Semarang City due to inefficient inputs. This is due to the lack of rejuvenation of infrastructure and the low maintenance of existing infrastructure. Infrastructure facilities that have not been optimal cause there is still garbage that has not been handled properly.

REFERENCES

- [1] Sharholy, M., Ahmad, K., Mahmood, G., Trivedi, R. C. Municipal Solid Waste Management in India Cities-A Review. *Waste Management*, 28 (2), 2008, pp.459-467.
- [2] National Standards Agency. SNI-19-2454-2002, Procedures for Operational Management of Urban Waste Management. Jakarta: National Standards Agency. 2013.
- [3] Callan, S. J. and Thomas, J. M. Environmental Economics And Management: Theory, Policy, And Applications. Ohio: Nelson Education, Ltd. 2013.
- [4] Hyman, D. N. Public Finance: A Contemporary Application Of Theory To Policy. Ohio: Nelson Education, Ltd. 2014.

- [5] Faizah. Community Based Household Waste Management (Case Study in Yogyakarta). (Thesis), Diponegoro University, Semarang. 2008.
- [6] Yuksel, H. Evaluating the Success of Waste Collection Programs of Municipalities with Data Envelopment Analysis. *International Journal of Environmental Protection*, 2 (5), 2012, pp. 6-8.
- [7] Okumura, S., Tasaki, T., Moriguchi, Y. and Jangprajak, W. Economic growth and selection of municipal waste treatment options in Bangkok. *Journal of Material Cycles and Waste Management*, 2, 2016, pp. 1-13.
- [8] Sjöström, M. and Östblom, G. Decoupling waste generation from economic growth — A CGE analysis of the Swedish case. *Ecological Economics*, 69 (7), 2010, pp.1545-1552.
- [9] Anderson, D. A. Environmental Economics and Natural Resource Management. New York, USA: Routledge. 2013.
- [10] Guerrero, L. A., Maas, G. and Hogland, W. Solid Waste Management Challenges For Cities In Developing Countries. *Waste Management*, 33(1), 2013, pp. 220-232.
- [11] Keim, M. E. Building Human Resilience: The Role of Public Health Preparedness and Response As an Adaptation to Climate Change. *American Journal of Preventive Medicine*, 35(5), 2008, pp. 508-516.
- [12] Central Bureau Statistics. Central Java in Figure 2014. Semarang: Central Bureau Statistics of *Central Java* and Regional Planning and Development Agency Central Java. 2014.
- [13] Alfi, M. 50 Tons of Trash in Semarang City are not Transported to Jatibarang Landfill. 2013. <http://jateng.tribunnews.com>. [Accessed: 5-January-2017].
- [14] The Hygiene and Landscaping Agency. Masterplan of Semarang City Solid Waste. Semarang: The Hygiene and Landscaping Agency of Semarang City. 2013.
- [15] Central Bureau Statistics. Data and Environmental Information of Central Java 2014. Semarang: Central Bureau Statistics of *Central Java*. 2016.
- [16] The Hygiene and Landscaping Agency. Jatibarang Landfill. Semarang: The Hygiene and Landscaping Agency of Semarang City. 2017.
- [17] Farrell, M. J. The Measurement Of Productive Efficiency. *Journal of the Royal Statistical Society. Series A (General)*, 120(3), 1957, pp. 253-290.
- [18] Charnes, A., Cooper, W. W. and Rhodes, E. Measuring The Efficiency Of Decision Making Units. *European Journal of Operational Research*, 2(6), 1978, pp. 429-444.
- [19] Banker, R. D., Charnes, A. and Cooper, W. W. Some Models For Estimating Technical And Scale Inefficiencies In Data Envelopment Analysis. *Management Science*, 30(9), 1984, pp.1078-1092.

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